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Individual Differences in Emotionality, Hypothesis Formation, Vicarious Trial and Error, and Visual Discrimination Learning in Rats

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INDIVIDUAL DIFFERENCES IN EMOTIONALITY, HYPOTHESIS FORMATION, VICARIOUS TRIAL AND ERROR, AND VISUAL DISCRIMINATION LEARNING IN RATS

FREDERIC M. GEIER, MAX LEVIN AND EDWARD C. TOLMAN[1]

University of California

The present study is an investigation of the interrelationships between measures of emotionality (4), hypothesis formation (7), vicarious trial and error (2, 9, 11) and visual discrimination learning in the white rat. Specifically, intercorrelations were calculated between 29 measures obtained in two experimental set-ups—an open field and a visual discrimination apparatus—and the resulting correlation matrix analyzed by the factor-analytic methods presented in Tryon's recent *"Cluster Analysis"* (12).

ANIMALS, EXPERIMENTAL SET-UPS, AND VARIABLES

Animals

A group of 57 male albino rats,[2] about four and one-half months of age at the beginning of the experiment, were tested in the two successive situations: an open field, and a simple white-black discrimination apparatus.[3]

The Open Field

The open field was a modification of that originally described by Hall and Ballachey (6). It was a circular area 9 feet in diam-

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The writers also wish to express their special indebtedness to Professor R. C. Tryon for continual counsel and advice.

[2] From the general colony maintained by the Psychology Department of the University of California.

[3] The whole group of animals was divided into 2 sub-groups one of which was tested by Mr. Geier and the other by Mr. Levin.

eter, bounded by a high metal wall and marked off in numbered squares to facilitate recording the movements of the animals. Each animal was removed separately from his home cage and placed alone in the field for two minutes a day on each of ten days. These ten experimental days followed each other in succession, save that an extra 24 hours elapsed between the fifth and the sixth day.

A total of eleven measures was obtained in this field situation. These consisted of seven direct and four derived measures. The seven direct measures (computed for the ten-day period) were:

1. Total number of defecations (boluses dropped).
2. Number of days on which defecation occurred.
3. Number of days on which urination occurred.
4. Active time, i.e., the time during which the animal indulged in any sort of activity, whether of the whole body in walking or of the head only.
5. Total distance traversed. The paths covered by the animals were traced on mimeographed sheets on which the field and its numbered squares were reproduced, and the lengths of line measured by a map measure.
6. "Washings," i.e., the number of times the animal lifted his forepaws to manipulate face or whiskers.
7. Rearings, i.e., the number of times the animal reared up on his hind legs.

The other set of field measures, derived from the above, were indices of "adaptation," or percentage changes from the first three days to the last three days or from the first four days to the last four days. Thus, for example, for defecations, the difference between the number of defecations on the first three days and the number on the last three days was divided by the total sum of defecations on the first three days plus the last three days. Rats defecating much less in the last period earned a high "adaptation" score; those whose defecations did not decrease suffered a low "adaptation" score. Four such adaptation measures were computed:

8. Defecations: percentage decrease in number, from first 3 to last 3 days.

9. Urinations: percentage decrease in days, from first 4 to last 4 days.
10. Distance: percentage increase, 3–3 days.
11. Washings: percentage increase, 3–3 days.

The direction of adaptation for each measure was determined by examining the direction of change of the daily scores over the 10-day period for the whole group of rats. The direction was down for defecation and urination, but up for distance and washings.

The Discrimination Set-up

A few days after the conclusion of the 10 days in the open field the animals were transferred to the discrimination apparatus. This was a modified form of the Lashley jumping apparatus (8) (Fig. 1).

In this discrimination apparatus two sets of measures were obtained: first a set of ten measures during preliminary training which lasted for 12 days and during which the animals were becoming familiar with the general set-up and were learning to jump the six-inch gap and to push through the stimulus cards; and second, a set of eight measures obtained during the learning trials proper.

The schedule of preliminary training trials ran as follows:

Days 1, 2, 3: Animals were placed by hand in the compartments of the food boxes. They were 24 hours hungry and food (wet mash) was available in the compartments. They were removed after an hour.

Day 4: Animals were placed by hand on the choice stand of the apparatus and allowed to find their way into the food compartments. Gap was 2.5″; no discrimination cards, one trial.

Days 5, 6: Animals were placed in starting compartments, from which they stepped out on to the choice stand and ran to food compartments. Gap was 2.5″; no cards, 1 trial each day.

Day 7: Same, but gap was 3″; 2 trials.

Day 8: First trial same, gap 3.5″; two further trials with two medium gray discrimination cards, both correct.

Day 9: Four trials with cards both correct; gap 3.5″.

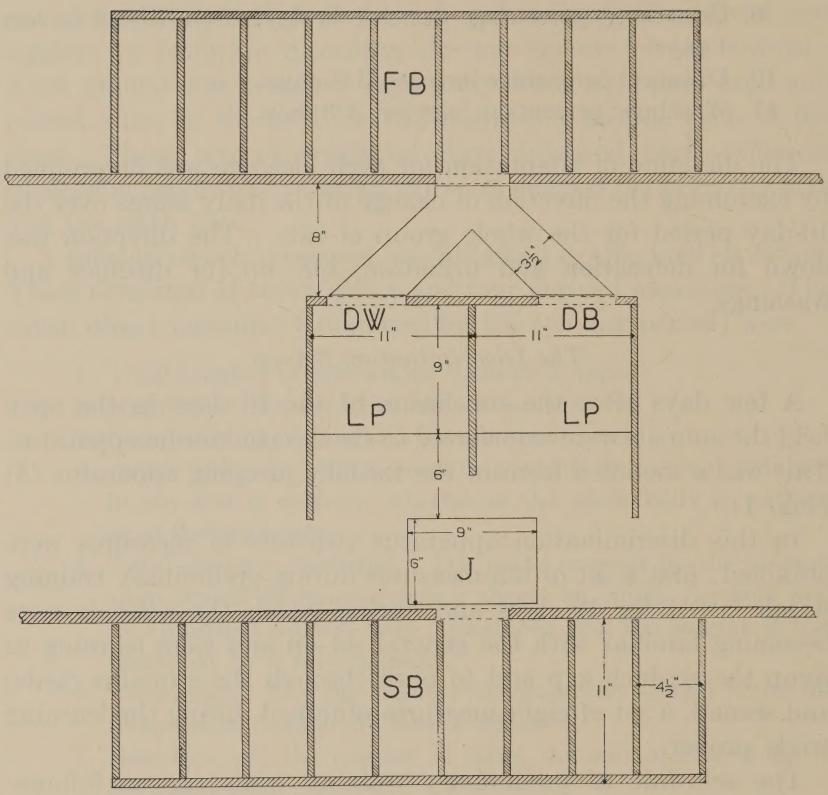

FIG. 1. DISCRIMINATION APPARATUS

From the starting box, *SB*, the animal was allowed to step out on to the jumping-off stand, *J*, from which he jumped on to either side *DW* or side *DB* of the landing platform, *LP*. If he chose correctly, he could then push through the discrimination card (hinged from the top) *DW* or *DB* and run into the food box, *FB*, where he obtained reward. If he chose incorrectly, he had to jump back to *J* and then again to the correct side. Gap = 6″.

Day 10: Four trials: on the first two, both cards were correct; on the third, left was incorrect; on the fourth, right was incorrect. Training to jump back and go to correct side when incorrect choice was made. Gap 4″.

Day 11: Four trials; correct sides RLLR. Gap increased to 5″.

Day 12: Same, LRRL; gap increased to 6″.

In the *preliminary training* the 10 measures obtained were:

12. Number of defecations in food boxes, days 1–3.
13. Eating in food boxes, days 1–3. This measure was the sum of ratings given on each of the three days. The ratings were: *2*, ate all; *1*, ate some; *0*, ate none.
14. Time to step out of starting box on to choice stand, days 5–8, total of 5 trials.
15. Rearings, days 4–5, total of 2 trials.
16. Time to reach food box from choice stand, days 4–8, total of 6 trials.
17. Retreating (no discrimination cards).
    Number of times animal retreated into starting box after having emerged on to choice stand, days 5–8, total of 5 trials. This measure was taken during the gradual widening of the jump gap.
18. Retreating (with cards, both correct). Same as 17, except for presence of cards; days 8–10, total of 7 trials.
19. Retreating (one card incorrect).
    Same as 17 and 18, except that the measure was computed from trials on which the animal encountered an "incorrect" discrimination card. Days 10–12, total of 10 trials.
20. Refuses to run (both cards correct).
    Number of trials animal refused to jump after 2 minutes, days 8–10, total of 7 trials.
21. Refuses to run (one card incorrect), days 10–12, total of 10 trials.

During the *discrimination training proper* each rat was given four trials a day for 54 days. All but 12 animals reached, within this period, the following criterion of learning: 15 correct trials out of 16 consecutive runs, or 18 correct out of 20, or 21 out of 24. The white card was correct, black incorrect; the sides on which they were presented were varied in random order, save that each card appeared twice left and twice right on each day. Three direct measures were obtained:

22. Days to learn: that is, the number of days to reach criterion of learning. (Each of the 12 animals who failed to learn obtained a score as if he had learned on the 54th day.)

23. Hesitation time: the average time per day of hesitation on choice stand before jumping.
24. "Vicarious trial and error" (VTE): the average number of head wags (VTE's) per day made on the choice stand. A wag from one discrimination card to the other is counted as one VTE. Both this variable and variable 23 were computed from trials until learning; trials after the criterion of learning was reached were not used.

Five derived measures were also obtained. These reflect primarily the kinds and strengths of "hypotheses" which the rats exhibited in the pre-solution period. For each animal, for each day, the sequence of responses was analyzed to discover systematic or nonsystematic trends (i.e., kinds of hypothesis made), and the percentages of types of hypothesis made by each rat were computed. The following categories of hypotheses were distinguished:

25. Position hypothesis, RRRR or LLLL.
26. Perseveration hypothesis: any day's sequence in which each response is determined by the previous correct response. Thus, the animal may consistently choose either that side which has proved correct on the immediately previous trial or that side opposite to the previously correct one.
27. Lack of hypothesis: any day's sequence which showed no determinable "system" or "principle."
28. Black-going hypothesis: animal chooses black discrimination card consistently.
29. Changes of hypothesis: this measure was computed from the average number of inter-day plus intra-day changes in hypotheses. The intra-day changes were those from which variable 27 was determined. An inter-day change would be, for example, one from a position hypothesis on one day (RRRR or LLLL) to a perseveration hypothesis on the next day.

Summary of Variables

1. Number of defecations.
2. Days of defecation.
3. Days of urination.
4. Active time.
5. Distance traversed.

6. Washings.
7. Rearings.
8. Defecations: decrease in number.
9. Urinations: decrease in days.
10. Distance: increase.
11. Washings: increase.
12. Defecations in food boxes.
13. Eating in food boxes.
14. Time to step out of starting box.
15. Rearings in discrimination apparatus.
16. Time to reach food box.
17. Retreating, no cards.
18. Retreating, cards, both correct.
19. Retreating, one card incorrect.
20. Refuses to run, both cards correct.
21. Refuses to run, one card incorrect.
22. Days to learn.
23. Hesitation time.
24. "Vicarious Trial and Error" (VTE).
25. Position hypothesis.
26. Perseveration hypothesis.
27. Lack of hypothesis.
28. Black-going hypothesis.
29. Changes of hypothesis.

It is evident that some of the measures taken—especially in the discrimination apparatus—are partially or wholly included in others. It follows that some of the intercorrelations are spuriously high. In all such cases the figure in the correlation table is placed in parentheses and the operations of the analyses have been modified to rectify consequent errors. Several variables (numbers 6, 17, 20, 21, 28) were excluded from the factor analysis because of such duplication with others, or because of the small number of significant correlations.

A possible objection arises in connection with our scoring of hypotheses since four trials per day are insufficient to make accurate scorings. This makes no qualitative difference in results, but does reduce the reliabilities of these measures and the *degree* of relationship found.

Reliabilities

The reliabilities (Pearson's product moment, odd vs. even days) of the more important variables are presented in Table 1.

It is obvious that an adequate measure of the reliability of the learning scores, variable No. 22, could not be computed, since a criterion was used yielding only one possible score per rat—either learned or not learned—and since individual differences in error scores up until learning were practically nonexistent. That it was at least .56 is indicated by its correlation of .75 with VTE, since the square of the maximum correlation of a variable may be taken as a minimal estimate of its reliability.

It is to be noted that measures of reliability are not essential to Tryon's cluster-orthometric analysis, since that part of the variance of a given variable due to unreliability is included with its unique components and can be disregarded in the determination of the structure of its remaining variance.

TABLE 1

Reliability Coefficients—Pearson r's

	UNCORRECTED	CORRECTED
1. Number of defecations	.773	.872
2. Days of defecation	.915	.956
3. Days of urination	.628	.771
4. Active time	.858	.924
5. Distance traversed	.923	.960
6. Washings	.869	.930
7. Rearings	.779	.876
24. VTE	.948	.973

RESULTS

Tetrachoric intercorrelations[4] are presented in Table 2.[5]

Certain significant relationships are immediately apparent. Observe the relatively high correlations between learning (No. 22) and VTE (No. 24) and the practically zero correlations of both learning and VTE with such measures of "emotionality" as defecation (No. 1) and active time (No. 4).

[4] Tryon's modification of Thurstone's method was used (12, 10). For justification of the use of tetrachoric correlations, see Tryon, op. cit., p. 115.

[5] Several variables have been "reflected" for purposes of analysis. See also below, footnote 10.

TABLE 2

Tetrachoric Intercorrelations

4	5	10	25	26	29	22	24	12	13	16	17	21	19	2	3	6	7	8	9	11	14	15	18	20	23	27	28	
.69	.66	.54	−.03	−.15	.19	.04	.09	.38	.08	.40	.52	.33	.43	(.91)	.48	.16	.49	(.75)	.42	.31	.13	.27	.15	.11	.11	−.01	.46	1. Number of defecations
	(.82)	.64	−.07	−.37	.13	.09	−.09	.25	.14	.34	.32	.31	.20	.61	.45	.28	(.84)	.40	.37	.15	.28	.46	.13	.06	−.16	.18	.10	4. Non-Active Time
		(.81)	−.25	−.17	.08	−.20	−.03	.22	−.03	.41	.20	.16	.07	.64	.63	.62	(.79)	.44	.39	.07	.14	.52	−.22	−.30	.17	.17	.13	5. Non-Distance Traversed
			−.19	−.08	.03	−.03	−.19	.48	.25	.36	.26	.22	.15	.60	.39	.39	.38	.38	.23	.13	.31	.48	−.15	−.23	−.23	.24	.27	10. Non-Increase in Distance
				(.79)	(.94)	.50	.53	−.07	.04	.03	.09	.31	.32	−.46	−.20	−.03	−.25	−.25	−.07	.65	.18	−.28	.25	.06	.07	.69	.51	25. Non-Position Hypothesis
					.70	.49	.61	−.19	−.15	−.04	.03	.32	.15	−.52	−.10	.20	−.37	−.39	−.24	−.04	.13	−.42	.20	.06	.41	.19	.45	26. Perseveration Hypothesis
						.30	.36	−.09	−.09	.03	.09	.50	.52	−.25	.03	.31	−.15	−.03	.03	.53	.20	−.31	.15	.08	−.03	(.85)	.38	29. Changes of Hypothesis
							.75	−.22	−.53	.07	.05	.36	.15	−.20	−.25	−.31	.03	−.31	−.14	.20	−.10	−.14	.44	.36	.64	−.09	.36	22. Speed of Learning
								−.19	−.40	.25	.20	.19	.20	−.13	−.41	−.03	−.15	−.24	−.20	.25	.30	−.10	.38	.31	(.79)	.09	.22	24. Vicarious Trial & Error
									.73	−.09	.16	.18	−.07	.49	.33	.32	.11	.32	.14	.03	.20	.00	−.01	−.05	−.29	−.05	.00	12. Defecations in Food-box
										−.09	−.04	−.03	−.04	.30	.12	.08	−.02	.40	.04	.04	−.15	.03	.13	−.05	−.58	.29	.10	13. Non-Eating in Food-box
											(.92)	.19	.19	.40	.25	.19	.30	.31	.03	−.20	.51	(.55)	.03	−.02	.41	−.02	−.07	16. Time to Reach Food-box
												.31	.39	.48	.02	.07	.34	.20	−.13	−.04	.45	.59	.20	.19	.41	.07	.03	17. Retreating, no Cards
													(.85)	.14	.17	.27	.06	.27	.09	−.03	(.45)	−.04	.48	.43	.44	.33	−.10	21. Refuses to run, 1 incor.
														.27	.13	−.05	.10	.07	.12	.20	.35	−.07	.07	.07	.31	.41	.03	19. Retreating, 1 incor.
															.70	.27	.45	(.91)	.67	.18	.04	.40	.33	.27	.05	−.18	.19	2. Days of Defecation
																.34	.24	.72	(.88)	−.20	.08	.23	.19	.04	−.08	−.19	−.23	3. Days of Urination
																	.34	.00	.27	−.37	.26	.10	.01	.15	−.07	.17	.00	6. Non-Washings
																		.23	.19	−.13	.03	.22	−.32	−.28	.20	−.28	.37	7. Non-Rearings
																			.83	.18	.25	.22	.47	.39	−.19	.05	.13	8. Non-Decrease in Defecation
																				.16	.40	.04	.28	.53	−.01	−.13	−.12	9. Non-Decrease in Urination
																					.07	.03	.13	.06	−.05	.50	.52	11. Non-Increase in Washing
																						.17	.06	(.25)	.35	.13	−.03	14. Time Step out of Starting-box
																							.10	.07	−.05	.19	−.43	15. Rearings in Discrim.-App.
																								(.97)	.25	.25	−.09	18. Retreating, both correct
																									.31	.21	−.03	20. Refuses to run, both cor.
																										−.38	.10	23. Hesitation time
																											.10	27. Lack of Hypothesis
																												28. Black-going Hypothesis

Such figures suggest the possibility of interesting underlying relationships. Hence, it seemed to us that some sort of a factor analysis should be applied. We used Tryon's method of orthometric-cluster analysis because it has the advantage of (1) a minimum of computational labor and (2) the finding of correlation profiles and clusters as a first step. These latter are easily obtained and indicate the extent to which a more detailed analysis is justified.

PROFILE ANALYSIS

Out first step was to group into clusters[6] those variables which had profiles of intercorrelation similar to those of other variables. Four clusters, with the profiles shown in Figure 2, were found. These clusters were made up as follows:

Cluster I: Open Field Timidity

Variable No.	Animal making *Low Score* on the cluster (i.e., little timidity) will show:	Animal making *High Score* on the cluster (i.e., much timidity) will show:
1	Little defecation	Much defecation
4	Much general activity (time)	Little general activity (time)
5	Much running about	Little running about
10	Great increase in distance	Little increase in distance

Weaker members of this cluster are:

Variable No.	*Low Score*	*High Score*
7	Much rearing	Little rearing
2	Few days of defecation	Many days of defecation
3	Little urination	Much urination

Cluster II: Hypothesis-Variability

Variable No.	*Low Score* (i.e., little variability)	*High Score* (i.e., much variability)
25	Many position hypotheses[7]	Few position hypotheses
26	Few perseveration hypotheses	Many perseveration hypotheses
29	Few changes of hypotheses	Many changes of hypotheses

[6] It should be carefully noted that the discussion deals first with "clusters" and their labels and then with "factors" and their labels. We regard the "clusters" as rough ordering devices facilitating the finer and more detailed analysis of underlying relationships which are then described finally in terms of the "factors."

[7] A "position hypothesis" is here practically equivalent to a "fixation," since animals tend to vary such "hypotheses" infrequently.

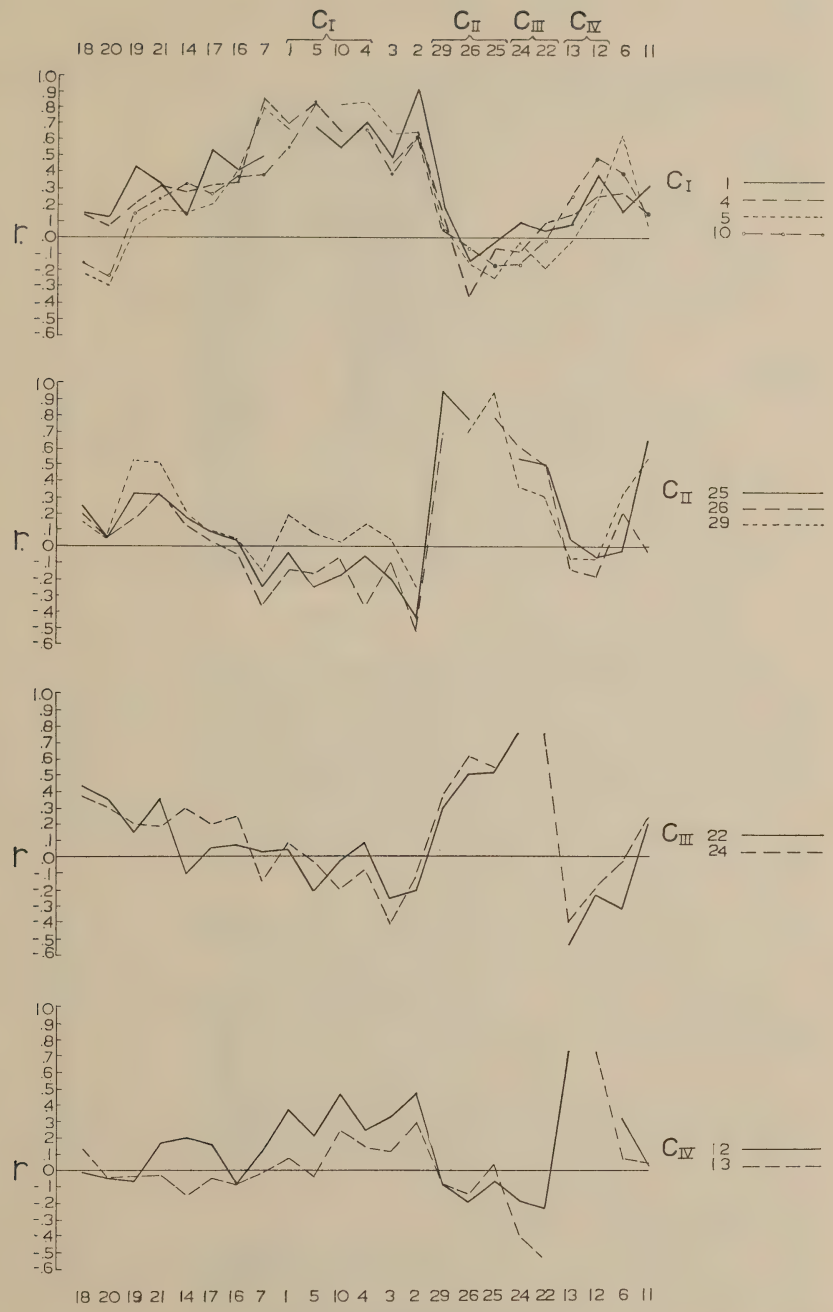

Fig. 2. Cluster Profiles

A second pair of variables, belonging loosely with Cluster II, we have kept separate as the main components of Cluster III.

Cluster III: Learning-VTE

Variable No.	*Low Score*	*High Score*
22	Slow learning	Rapid learning
24	Little VTE	Much VTE
	A weaker member of this group is:	
23	Little hesitation time	Much hesitation time

Cluster IV: Discrimination Apparatus Timidity

Variable No.	*Low Score*	*High Score*
12	Little defecation in food box	Much defecation in food box
13	Much eating in food box	Little eating in food box
	A weaker member of this group is:	
23	Much hesitation time	Little hesitation time

(It is to be noted that Variable No. 23 was also a weak member of Cluster III.)

FACTOR (ORTHOMETRIC) ANALYSIS AND FACTORGRAM

A further insight into the organization of these clusters and of the variables is obtained by the factor analytic method of describing the communality variance of each variable (i.e., only that part of each variable which is common to any parts of the remaining variables) in terms of a minimal number of orthogonal axes or factors. The results then will be described in terms of the percentage of the communality of each variable accounted for by each of the axes found necessary adequately to describe the intercorrelations. Each of the axes is so "located" in the common factor space as to be theoretically psychologically meaningful. These results are shown in the chart or "factorgram" presented in Figure 3.[8]

[8] The choice of axes was determined by the already obtained clusters. The first axis was passed through the centroid of Cluster I, the second through the residual centroid of Cluster III, the third through the residual centroid of Cluster II, the fourth through the residual centroid of Cluster IV. Since we are here dealing only with common factor space, the factor loadings of each test are "augmented" loadings. Rotation of axes was found to be unnecessary, since the two clusters through which the first two axes were passed happen to be completely independent, thus making possible the meaningful interpretation of these axes; and since the third axis happened to load almost completely a single variable, No. 27, facilitating the interpretation of that axis.

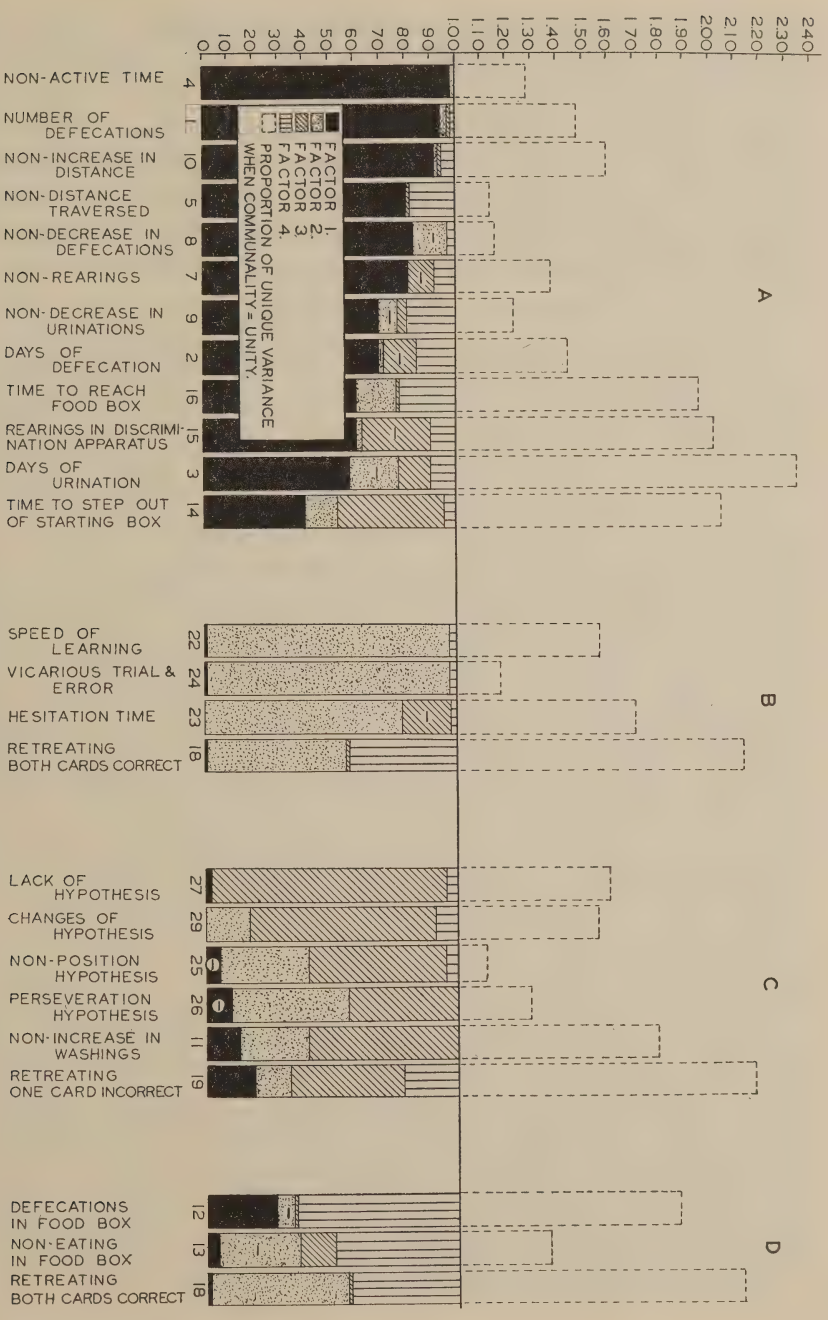

FIG. 3. FACTORGRAM

This factorgram[9] shows graphically the extent of structural similarity of the variables. The latter have been arranged according to similar factor loading patterns into four groups, A, B, C, and D (including, respectively, Clusters I, III, II, and IV). The meaning of each factor may be inferred by examining the content of those variables whose variances are wholly or almost wholly accounted for by it, or in general from the character of the group whose variables are most heavily loaded by it.[10]

Factor 1—"Open Field Timidity"

It is to be observed that Factor 1 (solid black area) loads all the variables in Group A very heavily. It is also to be observed that most of the variables in this group (i.e., all save Nos. 14, 15, and 16) were obtained in the open field. The latter three were obtained during the preliminary training in the discrimination apparatus. The meaning of this factor can perhaps best be inferred by examining the two variables whose variances are almost wholly accounted for by it—i.e., Nos. 4 and 1. A high score in Variable No. 4 represents a small amount of time spent in activity in the field, and a high score in variable No. 1 means many defecations in the field. The consideration of these two variables leads to the interpretation of Factor I as the possession of that type of psychological and physiological make-up which, for want of a better name, we may call "emotionality" or "timidity." Thus we observe that such "timidity" is the most important source of communality variance of variables in the open field. Moreover this same timidity carried over and

[9] This factorgram is, we believe, a new device for indicating relationships not previously used by other authors.

[10] Negative loadings have been eliminated as far as possible by "reflecting" the variables: that is, changing sign and variable name to its opposite. The following variables have been reflected: No. 4, active time changed to non-active time; No. 5, distance traversed to non-distance traversed; No. 6, washings to non-washings; No. 7, rearings to non-rearings; No. 8, decrease in defecations to non-decrease in defecations; No. 9, decrease in urinations to non-decrease in urinations; No. 10, increase in distance to non-increase in distance; No. 11, increase in washings to non-increase in washings; No. 13, eating in food box to non-eating; No. 22, days to learn changed to speed of learning; No. 25, position hypothesis to non-position hypothesis. Remaining negative loadings are indicated in the factorgram by negative signs.

contributed substantially to the variance of the preliminary training variables in the discrimination apparatus (Nos. 14, 15, 16).

The next important point we note is that timidity did *not* appear as a source of variance in Group B. In other words, timidity contributed neither negatively nor positively to learning or to VTE. This we feel to be one of our most important findings. It means that neither learning nor VTE is a function of timidity as measured in the open field and in the discrimination apparatus.

Finally, we note that Factor 1 also appears to a slight extent in a number of the variables in Groups C and D. These latter cases are variables in which such timidity might be expected to function—i.e., non-increase in washing (No. 11), retreating (No. 19), and defecation (No. 12).

Factor 2—"Cognitive Reactivity"

The proportions of variance accounted for by Factor 2 are indicated in the stippled areas. This factor, which is drawn through the residual of Cluster III, is the main source of variance of all the variables in Group B. It is especially evident in variables Nos. 22 and 24—speed of learning and VTE; and it contributes the major portion of the variance of each of these. Since Factor 2 has practically nothing in common with "timidity" and does appear predominantly in VTE and learning, we may tentatively label it "cognitive reactivity."

It must be noted, however, that from the evidence obtained by a number of previous investigators we cannot assume that such "cognitive reactivity" which we have here found in the visual discrimination apparatus is necessarily a general trait. For it has been shown by Commins *et al.* (3), Anderson (1) and Vaughn (13), that there are relatively low correlations between learning in mazes, learning in problem boxes, and learning in discrimination apparatuses. In short, learning capacity in rats seems always to be relatively specific to the problem. Hence, we assume that the VTE-ing and learning trait, "cognitive reactivity," which we have found as Factor 2, is relatively specific to our visual discrimination problem.

Let us examine the parts played by "cognitive reactivity" in the other two variables of Group B—Nos. 23 and 18. In the case of No. 23, hesitation time, the relationship is primarily mechanical since VTE, as such, takes time. The high loading of Factor 2 on variable No. 18, the tendency to retreat back into the starting box on introduction of the stimulus cards, seems quite reasonable considering that a readiness to react cognitively in the apparatus predisposes the animal to respond to new environmental features—cards-to-be-pushed-through. It is this same readiness which later predisposes the animal to VTE with respect to such stimulus cues.

It is to be noted that Factor 2 also appears to some extent in several of the variables of Groups C and D (and to a negligible extent in a few of the variables of Group A). Considering the variables in Groups C and D one at a time, we note that those rats who had high scores on Factor 2 were also to a greater or lesser extent the ones who were most ready to change hypotheses (No. 29), who did not adopt simple position hypotheses (No. 25), who tended to try out perseveration hypotheses (No. 26), who did not increase their washings[11] in the open field (No. 11), and who retreated when they first encountered incorrect cards (No. 19). The relations of these to "cognitive reactivity" are apparent. Variable No. 13, non-eating in the food box, is also substantially loaded, negatively, with Factor 2 (i.e., eating is related positively to Factor 2). Eating may well be an expression of strong motivation. And, if we assume that such a motivation extends into learning proper, then we are led to conclude that motivation is a partial determiner of "cognitive reactivity."[12]

Factor 3—"Unsystematic Variability"

The proportions of variance accounted for by Factor 3 are indicated in the diagonally hatched areas. This factor can best be defined in terms of variable No. 27, since almost 100 per cent

[11] If washing may be conceived as a "going-out-of-the-field," then the more cognitively reactive rats would be expected to do less washing.

[12] An experiment is now in progress by Tolman, Geier, and Minium in which the relations between motivation, VTE, and learning are being further investigated.

of the latter's common factor variance is accounted for by it. Variable No. 27 is "lack of hypothesis," that is, any day's sequence of responses which showed no determinable "system" or "principle." We shall therefore consider Factor 3 as "unsystematic variability." It appears in very considerable amounts in the tendencies to change hypotheses (No. 29), to make no position hypotheses (No. 25), and to make perseveration hypotheses (No. 26).[13] It also appears in the tendency not to increase washing (No. 11), and in retreating when the black card was first introduced (No. 19).

This "unsystematic variability" does not, it is important to note, either favor or hinder learning. That is, it does not appear as either a positive or negative loading in either variable No. 22 or No. 24.

In the light of this interpretation of Factor 3, consider now variable No. 23 in Group B. This variable—hesitation time at the choice point—is loaded not only with Factor 2—"cognitive reactivity" but also, negatively, to an appreciable extent with Factor 3. In other words, short hesitation times are associated with unsystematic variability; conversely, the rat who has a systematic hypothesis tends to take more time at the choice point than the rat who has none.

Factor 3 also appears to an appreciable extent in variable No. 14 in Group A. That is, the rat who is slow in leaving the starting box in the preliminary training tends later to exhibit no determinable hypothesis, i.e., to be unsystematically variable.

Finally, we note that Factor 3 appears to a lesser extent in variable No. 15. That is, little rearing in the discrimination situation has some relationship to unsystematic variability—the slap-dash rat does not rear.

Factor 4—"Non-Motivation"

This factor (variance represented in the vertically hatched areas) was drawn through the residual of Cluster IV. It appears

[13] The grouping of these four variables (Nos. 27, 29, 25, 26) is due, in part at least, to the mechanical interlocking of the measures. The more the position hypotheses the less, of necessity, the changes of hypothesis, perseveration hypotheses and lack of hypotheses.

in variable No. 12, defecation in the food box; in variable No. 13, non-eating in the food-box; and in variable No. 18, retreating when stimulus cards are presented.

Since this variance has not been taken up by the first "emotionality" or "timidity" factor, we must conceive it as something other than that sort of "emotionality." We suggest that it may be a "non-motivation" or "lack of drive" factor: unmotivated animals do not eat heartily, defecate,[14] and retreat into the starting box.

SUMMARY

Twenty-nine measures of emotionality, vicarious trial and error, hypothesis formation and discrimination learning were obtained on 57 male albino rats in two experimental situations—an open field and a modified Lashley visual discrimination apparatus.

Tetrachoric correlations were calculated and a "cluster-orthometric" analysis performed.

Fifteen of the variables fell into four clusters:

I. Open Field Timidity, including defecation, non-activity, non-ambulation, non-rearing, and urination.

II. Hypothesis Variability, including non-position hypothesis, perseveration hypothesis and change of hypothesis.

III. Learning and VTE, including also perhaps hesitation time.

IV. Discrimination Apparatus Timidity, including defecation in food box, non-eating in food box, and possibly hesitation time.

Four factors were found necessary adequately to describe the intercorrelations.

Factor I: Open Field Timidity. This loads substantially all the measures in the open field, to some extent a few of the preliminary training measures in the discrimination apparatus and either insignificantly or not at all the final measures taken in the discrimination apparatus (i.e., learning, VTE, hesitation time, types of hypothesis formation). This type of "emotionality" is quite pervasive once it is aroused in a given situation, involving several different behaviors (i.e., defecation, urination, non-

[14] Cf. Hall's finding of the relationship between "Need and Emotionality" (5).

activity, non-rearing). It is not, however, a permanent and continuous behavior-appurtenance, but requires the introduction of a strange new situation to elicit it, and disappears on being exposed to such a situation for a sufficiently long time. Its relation to what might be called a general "neurotic instability" is questionable since its relation to learning, hypothesis formation, and choice point behavior in general is negligible.

Factor 2: Cognitive Reactivity. This loads learning, VTE, hesitation time, and to a lesser extent the hypothesis formation variables, and a few of the preliminary training variables. Learning and VTE are highly correlated, heavily loaded with Factor 2, and not at all with Factor 1. Because of the variables with which it is highly correlated, we believe that *VTE is to be considered a "cognitive" and not an "emotional" behavior manifestation.* Its relation to hypothesis formation also indicates its cognitive character. Finally, this cognitive reactivity is presumably specific to the given visual discrimination learning because of the low correlations found by other authors between different types of learning problem.

Factor 3: Unsystematic Variability. This partially loads the hypothesis-formation variables. It also loads some of the field variables and preliminary training variables to a lesser extent. It also loads hesitation time (negatively) to a moderate degree. Its loading with variable 11, increase in washings, suggests that the latter may be a "going-out-of-the-field" device.

Factor 4: Non-Motivation. This loads the preliminary training variables—defecation and non-eating in the food-box, and retreating. It also loads slightly some of the open field variables. This evidence agrees with Hall's finding of a relationship between strength of need and emotionality.

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